REMARKS/ARGUMENTS

Favorable reconsideration of this application in light of the present amendment and the following discussion is respectfully requested.

Claims 1-2 and 27-45 are presently active in this application. Claims 1, 2, 27, and 28 have been amended by the present amendment to define that the claimed ceramic substrate has a heating element pattern that includes a heating element layer and a protective layer protecting the heating element layer from oxidation, as supported on pages 18, lines 10-22, and page 26, lines 24-33, and in Figures 8 and 9 of the specification. Claims 41-42 have been added defining features of the protective layer cited in the above-noted parts of the specification. Claims 43-45 have been added defining features of the heating element layer supported on page 17, lines 2-32. Thus, no new matter has been added.

In the Official Action, Claims 1, 2, and 29-40 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. Claims 1, 2, 29, 31-34, and 36-39 were rejected under 35 U.S.C. § 102(e) as being anticipated by Yamada et al (U.S. Pat. No. 6,134,096). Claim 27, 28, and 30 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Tamagawa et al (U.S. Pat. No. 5,777,838), Grimard et al (U.S. Pat. No. (5,903,428), or Imai (U.S. Pat. No. 5,738,165). Claim 35 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Kobayashi et al (U.S. Pat. No. 5,908,799). Claim 40 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Yoshida et al (U.S. Pat. No. 5,908,799) or Kawanabe et al (U.S. Pat. No. 6,133,557).

Firstly, Applicants acknowledge with appreciation the courtesy of Examiner Paik to conduct an interview for this case on October 7, 2004 to discuss the outstanding issues in this case. As noted on the Interview Summary Sheet, clarifications to the point contact defined in the claims were discussed. Further, changes to the independent claims were discussed

regarding features that could distinguish the claims from the prior art. No agreement on patentability was reached during the interview.

I. Aspects of the present invention

One aspect of the present invention, as defined in Claim 1, relates to an air-compatible ceramic heater for heating a semiconductor wafer, the ceramic heater having a ceramic substrate on a surface of which a heating element pattern is formed. The ceramic substrate includes a ceramic sintered body containing at least one of Na, B, and Y as an impurity element. The ceramic heater is constituted to have a structure such that a convex body or a convex portion which can contact the semiconductor wafer is formed on the surface of the ceramic substrate, and the semiconductor wafer can be held apart from a surface of the ceramic substrate and heated by heat of the ceramic substrate in an oxygen-containing ambient. The ceramic substrate includes a heating element pattern having a heating element layer and a protective layer protecting the heating element layer from oxidation.

Another aspect of the present invention, as defined in Claim 2, relates to an air-compatible ceramic heater for heating a semiconductor wafer, the ceramic heater having a ceramic substrate on a surface of which a heating element pattern is formed. The ceramic substrate includes a ceramic sintered body containing at least one of Na, B, and Y as an impurity element. The ceramic heater is constituted to have a structure such that a face of the ceramic substrate on which no heating element is formed or one face of the ceramic substrate is made to be a heating surface. A convex body or a convex portion which can contact the semiconductor wafer is formed on the surface of the ceramic substrate, and the semiconductor wafer can be held apart from the heating surface and heated by heat of the ceramic substrate in an oxygen-containing ambient. The ceramic substrate includes a heating

element pattern having a heating element layer and a protective layer protecting the heating element layer from oxidation.

Another aspect of the present invention, as defined in Claim 27, relates to an air-compatible ceramic heater for heating a semiconductor wafer, the ceramic heater having a ceramic substrate on a surface of which a heating element pattern is formed. The ceramic substrate includes a ceramic sintered body containing at least one of Na, B, and Y as an impurity element. The ceramic heater is constituted to have a structure such that a convex body or a convex portion, which has at least one of a conical shape, a pyramidic shape, a spire shape, a spherical shape and a hemispherical shape, is formed on the surface of the ceramic substrate. The semiconductor wafer can be held apart from a surface of the ceramic substrate and heated by heat of the ceramic substrate in an oxygen-containing ambient. The ceramic substrate includes a heating element pattern having a heating element layer and a protective layer protecting the heating element layer from oxidation.

Another aspect of the present invention, as defined in Claim 28, relates to an air-compatible ceramic heater for heating a semiconductor wafer, the ceramic heater having a ceramic substrate on a surface of which a heating element pattern is formed. The ceramic substrate includes a ceramic sintered body containing at least one of Na, B, and Y as an impurity element. The ceramic heater is constituted to have a structure that a face of the ceramic substrate on which no heating element is formed or one face of the ceramic substrate is made to be a heating surface. A convex body or a convex portion, which has at least one of a conical shape, a pyramidic shape, a spire shape, a spherical shape, and a hemispherical shape, is formed on the surface of the ceramic substrate, and the semiconductor wafer can be held apart from the heating surface and heated by heat of the ceramic substrate in an oxygen-containing ambient. The ceramic substrate includes a heating element pattern having a

heating element layer and a protective layer protecting the heating element layer from oxidation.

Hereinafter the above aspects of the present invention are referred to as "the present invention."

Generally, thermal conductivity of a ceramic is lower than that of a metal. The thermal conductivity of AlN is 180 W/m•K at the highest, but it is still lower than the thermal conductivity of Al (236 W/m•K) or Cu (403 W/m•K). Therefore, on the heating surface of the ceramic substrate, an uneven temperature distribution is generated. In other words, a higher-temperature portion having a pattern similar to the heating element pattern is generated.[1]

The ceramic substrate of the present invention includes impurity elements such as Na, B and Y. Thus, there is a possibility that a semiconductor wafer will be contaminated upon exposure to the heated ceramic substrate. According to the present invention, a convex body or a convex portion is formed on the surface of a ceramic substrate. With this constitution, a semiconductor wafer is held apart from the heating surface of the ceramic substrate in substantially a point contact manner. The semiconductor wafer can be uniformly heated since heating is not affected by the uneven temperature distribution. Additionally, since the convex body or the convex portion makes a substantial point contact with the semiconductor wafer, the semiconductor wafer is not contaminated by impurities in the ceramic substrate. Accordingly, the ceramic heater of the present invention solves problem specific to ceramic heaters having impurities.

Moreover, since the convex body or the convex portion is formed on the surface of the ceramic substrate, there is no temperature difference between the ceramic heating surface

[1] Metal heaters do not have problems such as the uneven temperature distribution and contamination of a semiconductor wafer. Further, since metal has a high thermal conductivity, the temperature of the heating surfacc is kept uniform.

and the convex body or the convex portion. Thus, the semiconductor wafer is not partially cooled when it contacts with the convex body or the convex portion.

Furthermore, since the ceramic heater of the present invention is made of ceramic materials and since the heating element pattern includes a heating element layer and a protective layer protecting the heating element layer from oxidation, the ceramic heater of the present invention can be operated in an air ambient with oxidation/degradation of the heated ceramic surface or the heating element layer. As such, Applicants submit that the ceramic heater of the present invention can be used for example in the drying of semiconductor die following wet chemical processing or can be used for ion implantation activation anneals or can be used for oxide annealing in oxygen-containing atmospheres or can be used in other oxygen-containing atmospheres, without degradation of the heater and/or without contamination of the semiconductor wafer by the above-noted impurities in the ceramic.

II. The rejection of Claims 1, 2, and 29-40 under 35 U.S.C. § 1112, second paragraph, as being indefinite

The claims have been amended to remove reference to a point contact. Thus, it is respectfully submitted that the 35 U.S.C. § 112, second paragraph, rejection has been overcome.

III. The rejection of Claims 1, 2, 29, 31 to 34 and 36 to 39 under 35 U.S.C. § 102(e) as being anticipated by Yamada et al

Yamada et al disclose an electrostatic chuck. The electrostatic chuck includes a substrate 18, an electrode 9, and a resistive heating element 19 (see Yamada et al, col. 11, line 29 to col. 12, line 26). Gas-introducing holes 42 are formed in the substrate 18, and

continued to a gas-diffusing depression 24A which surrounds a circular discoidal portion 27. Round projections 26 are provided on the discoidal portion 27.

As illustrated in Figs. 6 and 7 of Yamada et al, projections 26 are columnar, and contact with the object along a surface. The columnar projections are neither convex bodies nor convex portions contacting the semiconductor wafer. Webster defines convex as having a surface that curves outward, like the surface of a sphere. Furthermore, the projections do not have any one of a conical shape, a pyramidic shape, a spire shape, a spherical shape, and a hemispherical shape, as defined in Claims 27 and 28.

Moreover, the electrostatic chuck of Yamada et al, while including resistive elements, does not disclose or suggest a heating element pattern on a surface of the ceramic substrate and having a heating element layer and a protective layer protecting the heating element layer from oxidation. Rather, the resistive elements in Yamada et al are embedded into the body of a sintered ceramic substrate and embedded without a protective layer protecting the heating element layer (i.e., elements 19) from oxidation.

Attached Figure A depicts the theory of an electrostatic chuck (ESC) operated under vacuum conditions. Ceramic is insulating material, and polarizes in the presence of an electric field, as shown in Figure A. On the other hand, a semiconductor wafer does not polarize due to the presence of free charge in the semiconductor. When DC power is supplied, the ESC charges equal and opposite signs across the ceramic, producing for example in Figure A, a negative charge layer on top of the ceramic by which the semiconductor wafer is "clamped" to the ceramic by the Coulombic force. Charge on the semiconductor wafer induced from the ESC ***does not decrease*** or vanish.

Electrostatic chucks are typically used under vacuum conditions or low pressure conditions, used for example in vacuum handlers, physical vapor deposition, plasma enhanced chemical vapor deposition, or reactive ion etching. In plasma tools, the plasma

itself is a source of charge to the semiconductor wafer so that the charge on the semiconductor wafer induced from the ESC ***does not decrease*** or vanish.

On the other hand, attached Figure B depicts the theory of an electrostatic chuck (ESC) operated in air. Air is insulating material, and also polarizes. The charge on the semiconductor wafer in turn polarizes the air molecules by charge transfer to the air molecules, in which case the charge on the semiconductor wafer ***decreases*** or vanishes. Air frequently contains water vapor (i.e., humidity). Attached Figure C depicts the charge on an ESC in an air condition containing water vapor. When the water molecules contact the wafer, the charge on the semiconductor wafer can ionize the water molecules, and the charge on the semiconductor wafer is transferred to the water molecules, in which case the charge on the semiconductor wafer ***decreases*** or vanishes. As a result, it is not practical to use an ESC in air.

Hence, one of ordinary skill in the art would not be motivated to apply the ESC teachings of Yamada et al to the design of an air-compatible ceramic heater, and furthermore would not be motivated from the teachings of Yamada et al to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in Yamada et al.

Thus, for these reasons, the ceramic heater according to the present invention differs in constitution from the electrostatic chuck of Yamada et al. Thus, it is respectfully submitted that Claims 1, 2, 29, 31-34, and 36-39 are neither anticipated by nor made obvious in view Yamada et al.

Therefore, the rejection of Claims 1, 2, 29, 31 to 34 and 36 to 39 under 35 U.S.C. § 102(e) as being anticipated by Yamada et al is traversed.

IV. The rejection of Claims 27, 28, and 30 under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Tamagawa et al, Grimard et al, or Imai

The deficiencies in Yamada et al are not overcome by the teachings of Tamagawa et al, Grimard et al, or Imai.

Tamagawa et al likewise disclose an electrostatic chuck. The electrostatic chuck 10 includes a disc-shaped dielectric member 12, an electrode 14, and projections 28 (see Tamagawa et al, Figs. 1 and 2). The projections 28 in Tamagawa et al have a shape of a dome (see Fig. 3 therein) or a square pyramid (see Fig. 4 therein).

However, since Tamagawa et al relates to an electrostatic chuck and provides no disclosure of a heating element, Tamagawa et al do not disclose or suggest a heating element pattern having a heating element layer and a protective layer protecting the heating element layer from oxidation. Furthermore, since the electrostatic chuck of Tamagawa et al is not a ceramic heater, it does not have a contamination problem caused by heating. Consequently, Tamagawa et al do not teach or suggest the above-noted contamination problem caused by an impurity element.

Therefore, for these reasons and especially the fact that electrostatic chucks operating in vacuum and in low pressure conditions require no protective oxidation resistant coating, one skilled in the art would not be motivated from Tamagawa et al to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in Yamada et al. Hence, the present invention is not rendered obvious over Yamada et al in view of Tamagawa et al.

Grimard et al likewise disclose an electrostatic chuck. There are no resistive heating elements described in Grimard et al. Therefore, for similar reasons as with Tamagawa et al, one skilled in the art would not be motivated from Grimard et al to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in

Yamada et al. Hence, the present invention is not rendered obvious over Yamada et al in view of Tamagawa et al or Grimard et al.

Thus, for the electrostatic chuck teachings in Yamada et al, Tamagawa et al, and Grimard et al, attached Table I depicts the features of the present invention and those of Yamada et al, Tamagawa et al, and Grimard et al. The heater in Yamada et al, as noted above, is embedded in the ceramic substrate to protect the heater from the corrosive atmospheres disclosed in Yamada et al. No heaters are disclosed in Tamagawa et al, and Grimard et al. The heater in the present invention is formed on the surface (e.g., a bottom surface), and has a protective layer such as for example a metal layer such as one of those recited in Claim 41, or a glass layer as in Claim 42 protecting the heating element layer from oxidation. These features are not disclosed or suggested in the electrostatic chuck teachings or the non-electrostatic chuck teachings in the Office Action.

Regarding the non-electrostatic chuck teachings in this rejection, Imai discloses a substrate holding apparatus. As shown in Figs. 1 and 2 of Imai, the substrate holding apparatus includes the temperature regulating unit 8, and the substrate holding unit 7 placed on the temperature regulating unit 8. The substrate holding unit 7 is provided with a plurality of protruding portions 22, and is composed of a material of a high thermal conductivity and a low thermal expansion, for example, SiC (see col. 4, lines 39 to 42 therein). There are ***no resistive heating elements*** shown in Imai.

The temperature regulating unit 8 ***absorbs heat*** accumulated in the substrate holding unit 7 by contact with the substrate holding unit 7 (see Claim 1 of Imai). The substrate holding unit 7 is provided with a circulating path (i.e., a heat discharge unit 9) for circulating temperature-controlled fluid so as to cover the entire substrate holding unit 7. The fluid from a temperature control unit 11 is supplied to the circulating path 9 through a line 11a, and returns to the temperature control unit 11 through a line 11b. The temperature control unit 11

effects precise temperature control so as maintain the fluid at a substantially constant temperature (see col. 3, lines 33 to 42 of Imai). The temperature regulating unit 8 does not heat the substrate holding unit 7, but ***absorbs heat*** therefrom. Therefore, the temperature regulating unit 8 and the substrate holding unit 7 do not have heating elements.

Therefore, one skilled in the art would not be motivated from Imai to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in Yamada et al. Hence, the present invention is not rendered obvious over Yamada et al in view of Tamagawa et al or Grimard et al or Imai.

Therefore, the rejection of Claims 27, 28, and 30 under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Tamagawa et al, Grimard et al, or Imai is traversed.

V. The rejection of Claim 35 under 35 U.S.C. § 103 (a) as being unpatentable over Yamada et al in view of Kobayashi et al

Kobayashi et al describe a semiconductor-producing apparatus. Kobayashi et al describe the preparation of an aluminum nitride substrate from an aluminum nitride powder containing 500 ppm to 5000 ppm of carbon. Kobayashi et al do not remedy the deficiencies of Yamada et al. Kobayashi et al do not teach or suggest resistive heating elements. Therefore, one skilled in the art would not be motivated from Kobayashi et al to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in Yamada et al. Hence, the present invention is not rendered obvious over Yamada et al in view of Kobayashi et al.

Therefore, the rejection of Claim 35 under 35 U.S.C. § 103 (a) as being unpatentable over Yamada et al in view of Kobayashi et al is traversed.

V. The rejection of Claim 40 under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Yoshida et al or Kawanabe et al

Yoshida et al describe a wafer heating apparatus having a ceramic substrate 2 and a heating resistor 4 buried in the ceramic substrate 2. Yet, the heating resistor 4 in Yoshida et al is disclosed as:

> As the material to make the heating resistor 4 buried in the ceramic substrate 2, metals having high melting points such as tungsten, molybdenum, rhenium and platinum or alloys thereof, or carbides and nitrides of metals belonging to Groups IV4a, Va and Via in the Periodic Table of the Elements may be used. Among these materials, those having thermal expansion coefficients nearer to that of the ceramic substrate 2 are selected.[2]

There is no disclosure in Yoshida et al of a protective layer for the heating resistor 4.

Kawanabe et al describe a wafer holding member having: a base body made of an aluminum nitride based sintered body 10; and a heating resistor 12 embedded in the base body. Regarding the heating resistor 12, Kawanabe et al disclose that:

> On the other hand, the heating resistor 12 is made of a mixture of 90 to 99 wt % of at least one of W, Mo, WC, TiC and TiN, and 1 to 10 wt % of AlN. These components are limited in the above-mentioned ranges because of the following reasons. When the content of at least one of W, Mo, WC, TiC and TiN is less than 90 wt %, or when the content of AlN is more than 10 wt %, the electrical resistance value of the heating resistor 12 becomes too large and unstable, and suitable heating characteristics are not obtained. Conversely, when the content of at least one of W, Mo, WC, TiC and TiN is more than 99 wt %, or when the content of AlN is less than 1 wt %, the adhesion between the heating resistor 12 and the base body 11 is reduced. The content of at least one of W, Mo, WC, TiC and TiN should preferably be in the range of 93 to 96 wt %, and the content of AlN should preferably be in the range of 4 to 7 wt %,
>
> By containing AlN in the heating resistor 12, the adhesion to the base body 11 can be enhanced. Consequently, the base body 11 can be prevented from being cracked, and the heating resistor 12 can be prevented from being separated and disconnected even during quick heating.[3]

Thus, like Yoshida et al, there is no disclosure in Kawanabe et al of a protective layer for the heating resistor 12. Indeed, adding a protective layer to the heating resistor 12,

---

[2] Yoshida et al, col. 4, lines 41-48.
[3] Kawanabe et al, col. 7, lines 1-21.

without further teachings in Kawanabe et al, could risk separation of the heating resistor 12 from the base body 11.

Hence, neither Yoshida et al nor Kawanabe et al disclose or suggest a protective layer protecting the heating element layer from oxidation. Accordingly, one skilled in the art would not be motivated from Yoshida et al or Kawanabe et al to add a protective layer protecting the heating element layer from oxidation to the resistive heating elements 19 in Yamada et al. Accordingly, the present invention is not rendered obvious over Yamada et al in view of Yoshida et al nor Kawanabe et al.

Therefore, the rejection of Claim 40 under 35 U.S.C. § 103(a) as being unpatentable over Yamada et al in view of Yoshida et al or Kawanabe et al is respectfully traversed.

VI. Conclusion

Hence, having traversed the outstanding rejections, it is respectfully submitted that independent Claims 1, 2, 27, and 28 and the claims dependent therefrom patentably define over the applied prior art.

Consequently, in light of the present amendment and in view of the above discussions, the outstanding grounds for rejection are believed to have been overcome. This application as amended is believed to be in a condition for formal allowance. An early and favorable action to that effect is respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Ronald A. Rudder

Masayasu Mori
Attorney of Record
Registration No. 47,301

Ronald A. Rudder, Ph.D.
Registration No. 45,618

Customer Number
22850

Tel: (703) 413-3000
Fax: (703) 413 -2220
(OSMMN 06/04)

MM:RAR:clh

Attachments: Figure A, Figure B, Figure C, Table I

I:\ATTY\RAR\AMENDMENTS\212814US\AM7.DOC